Using Facial Expression and Body Language to Express Attitude for Non-Humanoid Robot

(Extended Abstract)

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ABSTRACT

This work investigates designing social interactions for robots that are large and sturdy, and whose bodies may be not built proportionally to human. A modified version of Baxter robot was used. We examined the usage of facial expression, social dialogue, and arm movement to make people feel comfortable to interact with the robot. Our results show that body language may play a more important role than facial expressions for such robots, and that the synchronization between speech and body movements is critical.

Categories and Subject Descriptors

J.4 [**Computer Applications**]: Social and Behavioral Sciences

Keywords

Robot Human Interaction

1. INTRODUCTION

In recent years, there has been an increasing interest in designing social robots to interact with people. Most social robots currently being used are light-weight and much smaller in size compared to people, such as Nao, Hanson, and robotic pets. This makes them naturally look non-threatening. In contrast, many robots used by rescue teams, law enforcement, and the military are designed with functionality as a higher priority, and thus, they do not appear very human-like and have limited means to support natural human-robot interaction. They are sometimes referred to as appearance constrained robots [1]. One of the challenges we face in designing the movements of a large and sturdy robot is how to make people feel comfortable interacting with it. To enable long-term natural interaction between robots and users, we strive to not only rely on safe, and dependable robotic movements, but also leverage research studying human-robot interaction and human social interaction to create a positive psychological experience with trust and comfort.

In this work, we started this exploration using a modified version of Baxter, a dual-arm robot by Rethink Robotics [2].

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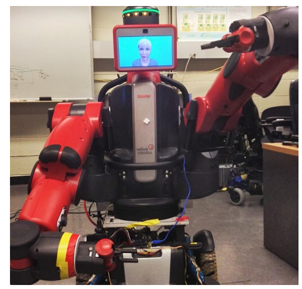

Figure 1: Modified Baxter Robot with Face

The robot by itself is 3'1" in height. Its arms can reach out 41". Though the arms have similar joints as a human's arms, the robot overall has a different upper body proportion from that of a human. Its body looks sturdy, with a weight of 165 lbs. The robot was installed on top of an electronic wheelchair, which makes its actual height similar to an adult. Figure 1 shows a picture of the robot. We conducted an empirical study and examined how using facial expressions, body movement and social dialogue can make people feel more comfortable to interact with the robot. In particular, because the robot's head display may need to be used for purposes other than showing an animated face, we investigated the importance of the robot having a face.

2. PROCEDURE AND IMPLEMENTATION

Each subject interacted with the robot individually. During the interaction, the robot first introduced itself, and then asked the subjects 10 questions about their lives or interests (to which they replied verbally on 7-point scales) and commented on their responses after all the questions had been answered. This part of the interaction lasted approximately 5 minutes. Afterward, the robot prompted the subject to approach it and shake its right hand but assured that they could decline to do so if they felt uncomfortable. If the subject decided to shake its hand, the robot would extend its arm as the subject approached.

The robot used text to speech. Its facial expressions and arm movements were designed by the experimenters to be synchronized with its speech and express a friendly attitude. ROS and Robot Raconteur [4] services were used for controlling the robot's arm movements. The Virtual Human Toolkit [3] was used for controlling the robot's facial expressions. We used the face and voice of a female char-

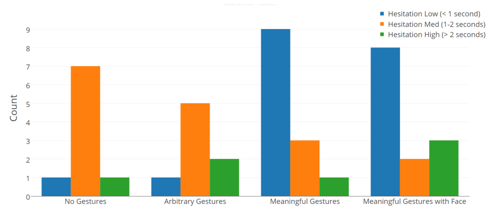

Figure 2: Hesitation to Shake Hands

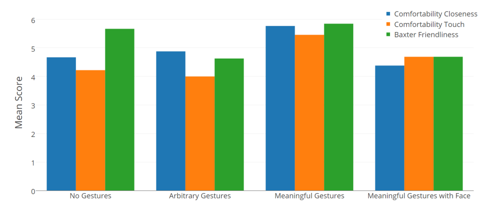

Figure 3: Subjective Ratings of the Robot

acter named Rachel from the toolkit. A Windows Forms application was developed in C#/.NET for communicating with these services and controlling the robot during the interaction. The experiment was conducted in a "Wizard of Oz"-style. When the subjects were asked questions, such as how difficult their schoolwork was or how often they listened to music, the experimenter recorded the answers and sent verbal and non-verbal commands to the robot using the Windows Forms application.

3. EXPERIMENTAL DESIGN

43 undergraduate students were recruited to participate. They were randomly assigned to one of four groups in a between-subjects design. **No Gestures** **(**$N = 9$**):** The robot used just voice and had neither arm movement nor facial expression during the interaction. **Arbitrary Gestures (**$N = 8$**):** The robot moved its arms randomly while speaking. **Meaningful Gestures (**$N = 13$**):** The robot's arm movements were synchronized with its speech. **Meaningful Gestures with Face (**$N = 13$**):** The robot's arm movements and facial expressions were both synchronized with its speech.

We measured a categorical dependent variable, **"hesitation,"** which represents how long the subject hesitated before approaching the robot when prompted to shake hands: "low" for less than 1s; "medium" for 1 and 2s, and "high" for more than 2 seconds, or looked to the experimenter for confirmation. After the interaction, all subjects rated on 7-point Likert scales for their comfortability interacting with the robot at a close distance ("comfortability closeness"), and their comfortability letting the robot use its arm to touch them ("comfortability touch"). In addition, for answering one of the questions the subjects rated how friendly the robot seemed ("friendliness"), which was also used as a dependent variable.

4. RESULTS AND DISCUSSION

A chi-square test of independence was conducted to examine the relation between the experiment condition and the amount of hesitation. The test showed a significant relationship, $X^2(6) = 15.46$, $p = 0.02$. No subjects declined to shake hands with the robot, but they differed significantly in the amount of time to approach the robot after the request. Of the standardized residual values, the differences were significant at the 0.05 level between the "Meaningful Gestures" group and "No Gestures" and "Arbitrary Gestures" groups for subjects in the low and medium hesitation categories. Overall, the subjects in the "Meaningful Gestures" group hesitated least in approaching the robot, and the subjects in the "No Gestures" and "Arbitrary Gestures" groups hesitated more often. A comparison of the hesitation measures of all conditions is shown in Figure 2.

Three ANOVA tests were conducted to evaluate the differences between groups on their perceived "comfortability closeness", "comfortability touch", and "friendliness". The mean scores for each condition in all measures can be seen in Figure 3. All ANOVAs were significant at 0.05 level. Post hoc comparisons using the Fisher LSD test were performed. For "comfortability closeness", the "Meaningful Gestures" group was significantly higher than the "No Gestures" and "Meaningful Gestures with Face" groups. For "comfortability touch", again, the "Meaningful Gestures" group was significantly higher than the "No Gestures" and "Arbitrary Gestures" groups. For "friendliness", the "Meaningful Gestures" group was significantly higher than the "Arbitrary Gestures" and "Meaningful Gestures with Face" groups, and the "No Gestures" group was significantly higher than the "Meaningful Gestures with Face" group. There were no significant differences between any other pairing of groups.

In general, the subjects were more likely to approach the robot without hesitation and perceived the robot as more friendly and trustworthy when they witnessed gestural arm movement beforehand, with or without the presence of a human face. Introducing irrelevant, arbitrary arm movement did not help, suggesting that the synchronization between arm movement and speech is critical to expressing attitudes. In a few cases, we observed that having a human-like face hurt the subjects' trust and perceived friendliness of the robot. This could be due to the uncanny valley effect. For future work, we will evaluate the role of facial expressions in more details and also study the effects of having longer term interactions between the robot and the user.

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